Hereinafter, embodiments of the invention will be described in more detail through experimental examples. The experimental examples are provided only for illustrating the embodiments of the invention and the embodiments of the invention are not limited thereto.

Experimental Embodiment 1

An n-type semiconductor substrate was prepared. Boron was doped to a front surface of the semiconductor substrate by an ion-implantation method, phosphorus was doped to a back surface of the semiconductor substrate by an ion-implantation method, and phosphorus was doped to the front surface of the semiconductor substrate by an ion-implantation method. A ratio of a doping amount of the phosphorous at the front surface: a doping amount of the boron at the front surface was 1:30. An ion-implanting energy of the phosphorous at the front surface was less than an ion-implanting energy of the boron. The semiconductor substrate was heat-treated for activation for 20 minutes at 1000° C.

An anti-reflection layer was formed on the front surface of the semiconductor substrate, and a second passivation layer was formed on the back surface of the semiconductor substrate. A first electrode electrically connected to an emitter layer and a second electrode electrically connected to aback surface field layer were formed to manufacture a solar cell.

Experimental Embodiment 2

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that the doping amount of the phosphorous at the front surface is five times that in Experimental Embodiment 1.

Experimental Embodiment 3

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that the doping amount of the phosphorous at the front surface is ten times that in Experimental Embodiment 1.

Experimental Embodiment 4

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that an ion-implanting energy of the phosphorus at the front surface is twice that in Experimental Embodiment 1. Accordingly, the ion-implanting energy of the phosphorus at the front surface was the substantially same as the ion-implanting energy of the boron at the front surface.

Experimental Embodiment 5

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that the ion-implanting energy of the phosphorus at the front surface is five times that in Experimental Embodiment 4.

Experimental Embodiment 6

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that that the ion-implanting energy of the phosphorus at the front surface is ten times that in Experimental Embodiment 4.

COMPARATIVE EXAMPLE

A solar cell was manufactured by the same method in Experimental Embodiment 1 except that the phosphorus was not doped to the front surface of the semiconductor substrate.

Leakage current (Joe) of the solar cells manufactured by Experimental Embodiments 1 to 6 and Comparative Example are shown in FIG. **7**. Carrier lifetime of the solar cells manufactured by Experimental Embodiments 1 to 6 and Comparative Example are shown in FIG. **8**. Open circuit voltage of the solar cells manufactured by Experimental Embodiments 1 to 6 and Comparative Example are shown in FIG. **9**.

Referring to FIG. **7**, it can be seen that the solar cells manufactured by Experimental Embodiments 1 to 4, and 6 had small leakage current. The result of the solar cell manufactured by Experimental Embodiment 5 was strange, and it is predicted to be induced due to the defects generated at the manufacturing process. Referring to FIG. **8**, it can be seen that the solar cells manufactured by Experimental Embodiments 1 to 6 had long carrier lifetime. That is, in the solar cells manufactured by Experimental Embodiments 1 to 6, it can be seen that the surface recombination was effectively prevented. Referring to FIG. **9**, it can be seen that the solar cells manufactured by Experimental Embodiments 1 to 6 had large open circuit voltage, and thus, had superior properties.

Also, referring to FIGS. **7** to **9**, it can be seen that the solar cells according to Experimental Embodiments 1 to 3 having relatively low ion-implanting energy of the phosphorus had properties better than the solar cells according to Experimental Embodiments 4 to 6. Also, it can be seen that the properties are enhanced more as the dopant amount of the phosphorus at the front surface decreases.

Certain embodiments of the invention have been described. However, the invention is not limited to the specific embodiments described above; and various modifications of the embodiments are possible by those skilled in the art to which the invention belongs without leaving the scope defined by the appended claims.

What is claimed is:

1. A method of manufacturing a solar cell, comprising:

forming a dopant layer to a first surface of a semiconductor substrate including a base dopant by doping a dopant of a first conductive type and a counter dopant of a second conductive type opposite to the first conductive type, wherein a doping amount of the counter dopant is less than a doping amount of the dopant of the first conductive type;

simultaneously activating the dopant of the first conductive type and the counter dopant of the second conductive type by a same heat-treatment process after forming the dopant layer; and

forming an electrode electrically connected to the dopant layer after activating the dopant of the first conductive type and the counter dopant of the second conductive type;

wherein the counter dopant is counter to the dopant of the first conductive type.

2. The method according to claim **1**, further comprising:

doping entirely the dopant layer with the dopant of the first conductive type; and

doping a part of the dopant layer with the counter dopant of the second conductive type.

3. The method according to claim **1**, wherein a ratio of the doping amount of the counter dopant of the second conductive type to the doping amount of the dopant of the first conductive type is 1:3 to 1:30.

4. The method according to claim **1**, further comprises doping the dopant of the first conductive type and the counter dopant of the second conductive type by an ion-implantation method, wherein an ion-implanting energy of the counter dopant of the second conductive type is less than an ion-implanting energy of the dopant of the first conductive type.

5. The method according to claim **1**, wherein the dopant layer to the first surface of the semiconductor substrate comprises a first portion adjacent to the electrode and a second portion other than the first portion, the method comprises doping the counter dopant of the second conductive type to the second portion and not to the first portion.

6. The method according to claim **1**, wherein the dopant layer to the first surface of the semiconductor substrate comprises a first portion and a second portion other than the first portion, the method comprises doping a different amount of